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Study of the reaction of the choice of combat athletes using computer technology

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Abstract

Purpose: to develop a methodology for evaluating the reaction of the choice of combat athletes using computer technologies and to conduct research on testing and determining its validity.

Materials and methods: the total number of participants in the study was 77 people (mean age: 13.8±0.7 years, 28% girls, 72% boys). To evaluate the choice reaction, the computer program «Visuomotor Choice Reaction» for mobile devices was developed and implemented. The following methods have been studied: analysis of scientific and methodological information and Internet sources; summarizing best practices; computer programming method; methods of mathematical statistics.

Results: the study was carried out in three stages. At the first stage, the correspondence of the selected colors and shapes to the tasks that should be solved during the test was determined. Measuring the speed of response to a single color and to individual shapes showed that the values are evenly distributed, the range of variation for the response to color was 50,7 ms, and the response to shapes was 133,4 ms. At the second stage, indicators of the reaction of choice were obtained and the operation of the computer program was tested in the "field conditions". The practical application of the program made it possible to obtain indicators of the reaction of the choice of taekwondo novice athletes and determine the stability of its work. The obtained data of the third stage determined the reliability and validity of the proposed method for assessing the reaction of choice.

Conclusions: based on the analysis of scientific and methodological literature and the competitive activity of martial artists of various specializations, conversations with coaches and qualified athletes, a computer program «Visuomotor Choice Reaction» was developed to assess the choice reaction. According to the results of the study of the reaction of choice of taekwondo novice athletes using the proposed methodology, in order to test it, it can be argued that the «Visuomotor Choice Reaction» computer program allows you to obtain indicators of sensorimotor reactions, is simple and reliable when using it. According to the results of the correlation and dispersion analysis, it can be argued that the proposed method for assessing the choice reaction is reliable and has a significant level of validity and meets all metrological requirements.

Анотація

В'ячеслав Романенко, Світлана П'ятисоцька, Юрій Тропін, Лукаш Ридзік, Наталія Бойченко. Дослідження реакції вибору єдиноборців з використанням комп'ютерних технологій. Мета: розробити методику оцінки реакції вибору єдиноборців з використанням комп'ютерних технологій та провести дослідження щодо апробації та визначення її валідності. **Матеріал, учасники та методи.** Загальна кількість тих, хто приймав участь у досліджені склало 77 осіб (середній вік: 13,8±0,7 років, 28% дівчата, 72% хлопці). Для оцінки реакції вибору було розроблено та впроваджено комп'ютерну програму «Visuomotor Choice Reaction» для мобільних пристроїв. В досліджені використані наступні методи: аналіз науково-методичної інформації та джерел інтернету; узагальнення передового практичного досвіду; метод комп'ютерного програмування; методи математичної статистики. **Результати:** дослідження було проведено в три етапи. На першому етапі було визначено відповідність обраних кольорів та фігур завданням, які треба вирішувати протягом тесту. Вимірювання швидкості реагування на окремий колір і на окремі

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фігури показало, що значення розподілені рівномірно, размах варіації для реакції на колір склала 50,7 мс, а для реакція на фігури 133,4 мс. На другому етапі були отриманні показники реакції вибору та перевірка роботи комп'ютерної програми в «польових» умовах. Практичне застосування програми дозволило отримати показники реакції вибору таеквондистів-новачків та визначити стабільність її роботи. Отримані дані третього етапу визначили надійність та валідність запропонованої методики оцінки реакції вибору. **Висновки.** На підставі аналізу науково-методичної літератури та змагальної діяльності єдиноборців різних спеціалізацій, бесід з тренерами та кваліфікованими спортсменами було розроблено комп'ютерну програму «Visuomotor Choice Reaction» для оцінки реакції вибору. За підсумками дослідження реакції вибору таеквондистів-новачків з використанням запропанованої методики, з метою її апробації, можно стверджувати, що комп'ютерна програма «Visuomotor Choice Reaction» дозволяє отримувати показники сеснсомоторних реакцій, проста та надійна при її застосуванні. За результатами проведеного кореляційного та дисперсійного аналізу можна стверджувати, що запропонована методика оцінки реакції вибору є надійна та має значимий рівень валідності та відповідає усім метрологічним вимогам.

Introduction

Visual sensorimotor reactions (simplified, simple, complex, combined) are used in psychophysiological diagnostics to determine the balance of the main nervous processes - excitation and inhibition, as well as to determine the state of a person's psychomotor development (Plokhikh, 2021).

Sensorimotor reactions reflect the unity of neurophysiological and mental processes and the interaction of sensory and motor components in the performance of all types of human mental activity. On the basis of sensory and kinesthetic information coming from the analyzers, the launch, regulation, control and correction of all types of psychomotor and the formation of cognitive functions in the process of individual human development are carried out. Coordination of sensory and motor components of a motor act has an expediently adaptive nature and at the same time is the most important condition for optimal interaction and functioning of the brain analyzer systems, which is the basis for the formation of adequate images of the surrounding world. When performing sensorimotor tests, the subject is usually offered various visual stimuli and the parameters of the person's extremely fast response to the action of the stimulus are recorded by a simple act predetermined by the experimenter (Malhazov, 2002).

Complex visual-motor reaction (CVMR) - the choice reaction is a type of complex sensorimotor reactions and, unlike a simple visual-motor reaction (SVMR), carried out to one light stimulus, registers the responses of a person to the presentation of several different light stimuli. According to this procedure, the process of information processing in the visual sensory system proceeds not only according to the principle of determining the presence or absence of a light signal by a person, but also according to the principle of distinguishing visual sensory stimuli by selecting a signal of the corresponding color (Malhazov, 2009).

Human cognitive activity largely depends on the functional state of the visual sensory system and the integrative activity of the brain. Due to the more complex cognitive process of information processing in the visual sensory system, the latent periods of the CVMR are longer in duration than the speed of the SVMR, that is, the time spent by the subject on the implementation of the motor act during the discrimination reaction is greater compared to a simple visual-motor reaction (Navroc'ka et al., 2017).

One of the most important indicators of effectiveness for athletes in martial arts is neuromuscular conduction and the dynamics and speed of muscle reaction associated with it. In this case, the advantage in the speed of response to various stimuli that differ in shape, size, color, etc is especially important. (Korobejnikova et al., 2021; Smyrnovs'kyj, 2017). For effective diagnostics of this type of reactions, it becomes necessary to create a standardized complex test task. It is most expedient to use special computer programs for its implementation, which, on the one hand, can be universal for many sports that require the manifestation of a complex visual-motor reaction, and on the other hand, the most appropriate types of reactions in martial arts. It should also be noted that the use of software products based on the most reliable operating systems and computer devices to date will make it possible to standardize the testing procedure as much as possible and minimize errors (Pjatisockaja et al., 2020).

The activity of an athlete in a competitive duel is associated with the constant influence on the visual analyzers of various constantly changing visual signals, namely the position of the arms, legs, torso of the opponent, the color of sports equipment, the color of the areas of the site (dayang, tatami, wrestling mat) where the duel takes place and others. Therefore, it is important for a martial artist to accurately and quickly recognize visual stimuli both in color and in shape.

Choice reaction is a person's ability to make the choice of an adequate response to a variety of stimuli as soon as possible in conditions of time and space deficit (Gucul, 2017; Rovnyj & Romanenko, 2016). This kind of complex reaction is very important in a sports duel. It allows the athlete to form rational attacking or counterattacking actions depending on the situation.

When implementing the reaction of choice, the information processing process takes place, including the reception of the signal, its analysis, the adoption of an execution strategy for its implementation, the implementation of this decision, and the motor act itself. This is due to the complex analytical-synthetic activity of the brain and the "switching on" of a different number of brain structures. The implementation of a complex reaction requires the inclusion of many functional units of the brain. The more difficult the task, the more these units are formed (Makarenko et al., 2018).

For a more detailed assessment of the reaction of the choice of combatants, it is necessary, when performing a test task, to create conditions that are close, in terms of their influence on the sensory mechanism of an athlete, to the conditions of a competitive duel.

Purpose of the study: to develop a methodology for evaluating the reaction of the choice of combat athletes using computer technology and to conduct a study to test and determine its validity.

Material and Methods of the research

Participants

The total number of participants in the study was 77 people (mean age: 13,8±0.7 years, 28% girls, 72% boys). The pedagogical research was carried out in three stages. The first stage involved 30 people of all ages (mean age: 17,8±1,43 years) and gender (girls 28%, boys 72%). Among the participants were those who are engaged in martial arts and not. In the study

at the second stage, novice taekwondo athletes (n=30, average age: 9,9±0,31 years, girls 23%, boys 77%) took part in the «Vulkan» Sports School of the Cherkasy City Council. The third stage was attended by persons of different genders (n=17, average age: 13,7±0,58 years, girls 35%, boys 65%), those who are engaged in martial arts and not.

All participants verbally consented to the study and were made aware of the purpose and procedures for testing and the possibility of withdrawing consent at any time for any reason. Participants under the age of 18 had their parents' consent to participate and were present during the study.

The study was conducted in compliance with the main bioethical provisions of the Council of Europe Convention on Human Rights and Biomedicine (dated April 4, 1997), the World Medical Association Declaration of Helsinki on ethical principles for medical research involving humans (1964–2008), as well as the Ministry of Health Ukraine No. 690 dated 09/23/2009

Methods

The following methods were used in the study: analysis of scientific and methodological information and Internet sources; summarizing best practices; computer programming method; methods of mathematical statistics.

Procedure

To assess a complex visual-motor reaction, a choice reaction, a computer program "Visuomotor Choice Reaction" was developed and implemented for mobile devices of the company Apple (iPad, iPhone, iPod).

As mentioned above, the pedagogical research was carried out in three stages. At the first stage, an algorithm for test tasks was developed and the features of the reaction to color and shape were determined. At the second stage, the developed methodology was tested. The indicators of the reaction of the choice of taekwondo novice athletes and general impressions about the work of the computer program in the "field conditions" were obtained. At the third stage, initial and repeated testing was carried out. A second test was performed three weeks after the first test. The reliability and validity of the proposed method for evaluating the reaction of choice has been determined.

Statistical analysis of the obtained data was performed using the STATISTICA program. To select the method of statistical analysis, the test results were checked for compliance with the normal distribution law using the Kolmogorov-Smirnov criterion. Spearman's rank correlation coefficient was used to determine the relationship between the results of the initial and repeated testing. The Kruskal-Wallis test was used to determine the reliability of the test (Bazylevych, 2016; Bezverhnja, 2011).

Results of the research

Based on the analysis of scientific and methodological literature (Kozina et al., 2011; Lyzohub et al., 2021; Podrigalo et al., 2017), analysis of the competitive activity of combatants of various specializations, conversations with coaches and qualified athletes, the computer program "Visuomotor Choice Reaction" to assess a complex visual-motor reaction, a reaction of choice.

The program "Visuomotor Choice Reaction" has the following options for conducting test tasks. Firstly, it is the ability to select the number of attempts at the stage (from 5 to 20). There is also the presence of the "Demo" mode, which offers the order of passing the test for review (2 attempts at each stage).

The "Visuomotor Choice Reaction" program has three test modes:

1. Test tasks that include responding to color and shapes;
2. Test tasks that include responding only to color;
3. Test tasks that contain responses only to shapes.

In each mode, you can select the time of occurrence of visual stimuli: 3…5 s; 2…5 s, 2…6 s, 3…8 s.

The first mode of the test is the main one, and the subsequent ones can be considered as training ones.

The test task (the first test mode) is divided into four stages, according to the principle from simple to complex, in terms of the impact on the sensory system. The reaction time for the shapes will be longer because there will also be more details that require reflection. The first stage is the response to colored stimuli, the second stage is the response to colored stimuli when counteracting the disruptive stimuli, the third stage is the response to the shapes, the fourth stage is the response to the shapes while counteracting the disruptive stimuli.

Based on a study of the competitive activity of combatants (Romanenko, Tropin, Kulida, 2021), the duration between active actions in a sports duel ranges from 3 s to 8 s. The time of occurrence of visual stimuli in the computer program was chosen in the range from 3 s to 5 s, which made it possible to obtain the required duration of the entire test. The duration of the test, with 10 attempts per stage (about 40 attempts for the entire test) is about 3 minutes, which corresponds to the duration of the round in many types of martial arts.

The stimuli that bring down these are colored balls or figures. During the stage, they randomly move across the screen of the mobile device at different speeds and image intensities (from 20 to 90%). The range of values for the emergence and changes of stimuli that confuse is selected from 0,2 s to 2,0 s. The duration of the movement of stimuli along random coordinates is 0,3 s, which ensures sufficient dynamics of their movement on the screen of a mobile device. The choice of colors of visual stimuli (Figure 1) used to create a computer program (yellow, green, red, blue and gray) was made based on the principles of color theory.

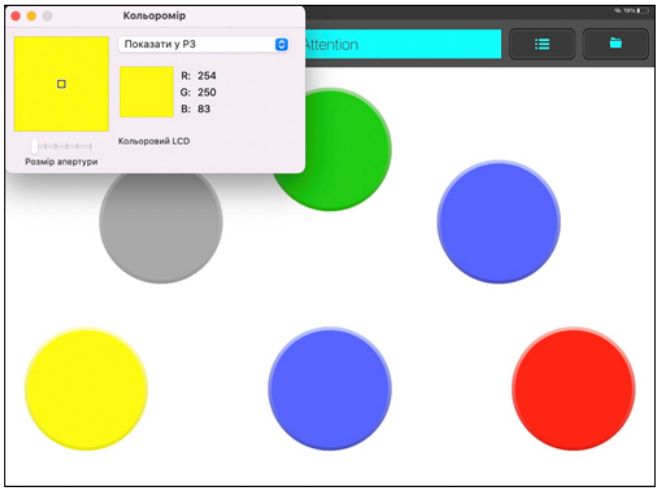

Fig. 1. Meaning of yellow color (DCI-P3 standard)

Johannes Itten (Swiss expressionist, artist, designer, teacher, writer and theorist). According to this theory, there are three primary colors: red, yellow and blue. The remaining colors of the color wheel are formed by mixing these three in different proportions (Simon, 2003).

When mixing colors according to the additive model, in addition to red and blue, there is also green. Gray is an achromatic color (colorless color), more precisely, the set of all colors obtained by combining red, green and blue in equal concentrations.

Color saturation was chosen experimentally. Saturation is the intensity of a certain tone, that is, the degree of visual dif-

ference between a chromatic color and an achromatic (gray) color equal in light. The intensity of a certain tone can be called «juicy», «deep», less saturated - «muffled», close to gray (Simon, 2003). The intensity of the tone of each color in the computer program is set in such a way that the visual perception of stimuli is at the same level.

According to the DCI-P3 (color space) standard, the color was set at (Figure 1): yellow - R: 254, G: 250, B: 83; blue - R: 90, G: 10, B: 246; green - R: 95, G: 199, B: 59; red - R: 234, G: 64, B: 37; gray - R: 169, G: 168, B: 169.

As mentioned above, the implementation of a complex reaction requires the inclusion of many functional units of the brain, the more difficult the task, the more of these units are formed, therefore, volumetric shapes were chosen as shapes for the test task, which have more various details for visual comprehension (Figure 2). The following shapes were chosen for the test task: Cylinder, Octahedron, Cube, Sphere, Square Pyramid. These figures are the most recognizable. The color of the figures was chosen to be gray as an achromatic color so that the test taker reacts to the figure and not to the color.

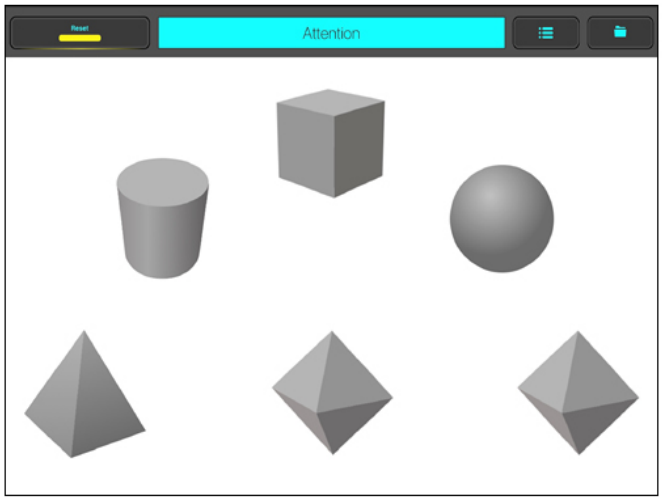

Fig. 2. Visual stimuli, shapes

The first stage of the study was devoted to determining the correspondence of the selected colors and shapes to the tasks that need to be solved during the test.

Measuring the speed of response to a single color and to individual shapes showed that the values are evenly distributed, the range of variation for the response to color was 50.7 ms, and the response to shapes was 133,4 ms, which may indicate that the user perceives visual stimuli fairly evenly (Figure 3).

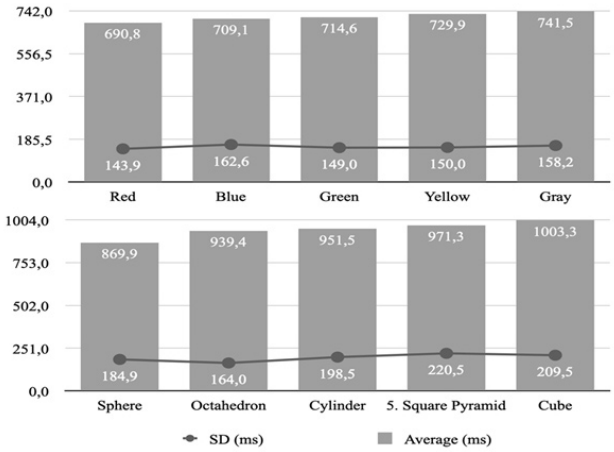

Fig. 3. Reaction time for colors and shapes

The response to the “Sphere” figure was 869.9 ms, this is confirmation that the response to an object that has less details for identification will be better than the response to more complex objects (Square Pyramid, Cube).

At the second stage, a pedagogical study was organized, the purpose of which was to obtain indicators of the choice reaction and to test the operation of the computer program “Visuomotor Choice Reaction” in the “field conditions”.

Table 1

Results of pedagogical testing of taekwondo novice athletes (n=30)

Stage	Time (ms) $\bar{X}\pm m$	SD (ms)	Error (n)
S1	815,0±47,7	151,0	0,20
S2	889,2±52,1	164,8	0,27
S3	1119,2±80,1	253,4	0,37
S4	1147,1±77,9	246,2	0,63

Note: stages of passing the test: S1 (first stage) is a reaction to color stimuli, S2 (second stage) is a reaction to color stimuli when counteracting distracting stimuli, S3 (third stage) is a reaction to shapes, S4 (fourth stage) reaction on the shapes under the counteraction of confounding stimuli

The testing methodology has a unified procedure for conducting and evaluating. To familiarize yourself with the test task in the computer program, there is a “Demo” mode that provides a clear and unambiguous understanding of the testing procedure by all its participants. As a result of testing the proposed methodology, it can be argued that it meets such a criterion as standardization.

To determine the reliability and validity of the proposed methodology for assessing the reaction of choice, a study was conducted. The results of the initial and repeated testing (n=17) were received. A second test was performed three weeks after the first test. During the study, the conditions for its conduct according to the regulations and requirements were clearly observed.

As for the reliability of devices (iPad, iPhone, iPod) on which you can install the “Visuomotor Choice Reaction” program, it can be argued that Apple’s mobile devices meet all user requirements regarding the accuracy and speed of measuring time intervals.

Also, the procedure for checking a software product before placing it in the App Store (mobile application store) provides the user with an additional guarantee for its use.

To select the method of statistical analysis, the test results were checked for compliance with the normal distribution law according to the Kolmogorov-Smirnov criterion. Since the results in the groups do not correspond to the law of normal distribution, Spearman’s rank correlation coefficient was used to determine the relationship between the results of the primary and secondary testing (Table 2). It was determined that the correlations are close between all stages of the test and are at a significant level ($p<0,05$), which indicates a high level of reproducibility of the test results after a given period of time.

Further, for the analysis, the Kruskal-Wallis test was used - this is a non-parametric alternative to one-dimensional (between-group) analysis of variance. It allows to test null hypotheses, according to which different samples were taken from the same distribution, or from distributions with the same medians. This type of analysis is recommended by experts to determine

the reliability of the test (Bazylevych, 2016; Kostjukevych et al., 2016). The analysis was carried out separately to compare the results of each stage of the test with the retest (Table 3).

Table 2

Results of the correlation analysis according to the Spearman coefficient between groups after the primary and secondary testing

Stage	S1	S2	S3	S4
S1	0,685*	-	-	-
S2	-	0,761*	-	-
S3	-	-	0,877*	-
S4	-	-	-	0,723*

Note: * significance at p<0.05. Stages of passing the test: S1 (first stage) is a reaction to color stimuli, S2 (second stage) is a reaction to color stimuli when counteracting distracting stimuli, S3 (third stage) is a reaction to shapes, S4 (fourth stage) reaction on the shapes under the counteraction of confounding stimuli.

Table 3

Comparison of the reaction time of choice between the individual stages of the test in the groups of primary and secondary testing according to the Kruskal-Wallis test

Stage	Primary (I) / Secondary (II)	Sum of Ranks	Mean Rank	Kruskal-Wallis test (H)	P
S1	I	324,50	19,09	0,865	0,352
	II	270,50	15,91		
S2	I	310,50	18,26	0,201	0,654
	II	284,50	16,74		
S3	I	328,50	19,32	1,140	0,286
	II	266,50	15,68		
S4	I	307,00	18,06	0,107	0,743
	II	288,00	16,94		

Note: Stages of passing the test: S1 (first stage) is a reaction to color stimuli, S2 (second stage) is a reaction to color stimuli when counteracting distracting stimuli, S3 (third stage) is a reaction to shapes, S4 (fourth stage) reaction on the shapes under the counteraction of confounding stimuli.

Since the reliability of all calculated Kruskal-Wallis coefficients turned out to be greater than the critical level (p>0.05), it can be argued that there are no significantly significant differences in the distributions of the results of the primary and secondary testing of the choice reaction time at each of the test stages, taking into account internal and external group variation.

Discussion

Many scientists have studied the sensorimotor reactions of athletes in different sports, so Iermakov et al. (2016) compared the indicators of sensorimotor reactions in athletes of boxing and wrestling martial arts, on the basis of which they established the most significant psychophysiological qualities for success in martial arts.

Korobejnikov et al. (2016) found a connection between the fighting styles of qualified boxers and psychophysiological characteristics.

Pervachuk et al. (2016) developed model characteristics of sensorimotor reactions and specific perceptions of qualified Greco-Roman wrestlers and offered practical recommendations for improving the training process.

Shevchenko et al. (2021) made a comparative analysis of the indicators of sensorimotor reactions of wrestlers and athletes of sports games with rackets.

Romanenko et al. (2022) conducted an analysis of the preparedness of highly qualified wrestlers based on the assessment of sensorimotor reactions, on the basis of which the characteristics of some aspects of the preparedness of athletes were formed.

Gorelov et al. (2021) in their research to analyze the benefits of sensorimotor response tests and the analysis of competitive progress in modern mixed martial arts.

Lyzohub and others. (2021) studied the speed characteristics of simple and complex visual-motor reactions of choosing one and choosing two excitatory and inhibitory signals to assess the individual typological properties of the central nervous system (CNS) in adolescents aged 10-11 years. The results of their research show that the speed characteristics of complex neurodynamic acts, in contrast to simple ones, can be used as quantitative characteristics of the typological properties of the CNS.

Korobejnikov et al. (2021) to assess the state of psychophysiological functions, they proposed the complex of psychodiagnostics “Multpsychometr-05” and found that the study of the psychophysiological state of wrestlers and the possibility of using this methodological complex should be used for the needs of current control.

Ouergui et al. (2021) investigated physiological and sensorimotor responses to taekwondo sessions depending on different zone sizes and sparring partners in a round.

Ceccarelli et al. (2019) conducted an analysis of self-compassion and psychophysiological recovery after the mentioned sports failure. It has been found that self-compassion promotes adaptive physiological and psychological responses in athletes to sports failure and may have implications for improved performance, recovery, and health outcomes. In addition, addressing athletes’ fears of self-compassion may also be important to promote optimal psychological recovery.

Summing up, we can say that the process of training athletes of different sports should be based on the indicators of sensorimotor reactions. The conditions for conducting test tasks to determine sensorimotor reactions, if possible, should correspond to the conditions of the competitive activity of single combat athletes. The advantage of the proposed technique is that the computer program “Visuomotor Choice Reaction” during testing allows you to create conditions that more accurately reflect the activity of a single combat athlete in terms of their influence on sensory mechanisms. Also, the ability of the program to demonstrate visual signals, different in color or shape, will allow researchers to identify the characteristics of the perception of athletes of various sports and qualifications.

The method for evaluating the choice reaction proposed in this study can be recommended for use both in martial arts and in other sports that require this type of reaction, in particular sports games.

Prospects for further research will be aimed at assessing

the complex visual-motor reaction, the choice reaction of athletes in different sports.

Conclusions

The analysis of scientific and methodological information and the generalization of advanced practical experience made it possible to establish that martial arts are sports with a significant variability of motor activity and high requirements for the speed of response to the opponent's actions during the fight. Therefore, the diagnosis of the ability to respond quickly, especially in the face of distractions, is of great importance in pedagogical control.

Based on the analysis of scientific and methodological literature and competitive activity of martial artists of various specializations, conversations with coaches and qualified athletes, a computer program "Visuomotor Choice Reaction" was developed to assess the choice reaction.

According to the results of the study of the reaction of the choice of taekwondo novice athletes using the proposed methodology, with the aim of testing it, it can be argued that the "Visuomotor Choice Reaction" computer program allows you to obtain indicators of sensorimotor reactions, is simple and reliable in its application.

According to the results of the correlation and dispersion analysis, it can be argued that the proposed method for assessing the choice reaction is reliable and has a significant level of validity and meets all metrological requirements.

Author Contributions

Vyacheslav Romanenko: collection, data entry, data analysis, manuscript preparation, statistics. Svitlana Piatysotska: design, data interpretation. Yuriy Tropin: data interpretation, analysis and literature search. Łukasz Rydzik: design, data interpretation. Valerii Holokha: design, study planning. Natalia Boychenko: research planning.

Conflicts of Interest

The authors declare no conflict of interest.

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